

COMPLIANT CONNECTOR FOR LAND GRID ARRAY

FIELD OF THE INVENTION

The present invention relates to apparatus and methods for providing electrical continuity
5 between two objects, and more particularly to an array of solderless connectors for use with a
land grid array integrated circuit package.

BACKGROUND OF THE INVENTION

Land grid array (LGA) connector assemblies are commonly used with integrated circuit
10 (IC) packages, such as in applications which do not require soldering of the pins of the LGA
connector assembly to either the IC package or a corresponding circuit board. As one example,
an LGA connector assembly can be used to temporarily place an LGA package in electrical
communication with a circuit card during test, emulation, and debug procedures. As another
example, the LGA socket assembly can be used for upgrades and replacements of LGA packages
15 onto circuit boards.

The present invention incorporates a variety of novel and unobvious features which are
improvements over currently existing LGA socket assemblies.

SUMMARY OF THE INVENTION

One aspect of the present invention includes an apparatus for providing electrical continuity between two objects. The apparatus includes a body with a top surface and a bottom surface, the body defining a plurality of pin receptacles, each receptacle including a guiding slot within the body between the top and bottom surfaces. The apparatus includes a plurality of pins, each one of the pins being located within a different one of the plurality of receptacles, each pin including a centerbody with two edges, a first member extending from the centerbody, a first cantilever beam extending from the centerbody, and a second cantilever beam extending from the centerbody. The first member of each one of the plurality of pins cooperates with the guiding slot of the corresponding receptacle to guide the pin within the receptacle, each pin being freely moveable within the corresponding receptacle.

Another aspect of the present invention includes an apparatus for providing electrical continuity between two objects. The apparatus includes a body with a top surface and a bottom surface, the body defining a plurality of pin receptacles, each receptacle including an aperture. The apparatus includes a plurality of pins, each one of the pins being loose within a different one of the plurality of receptacles, each pin including a centerbody, a first cantilever beam extending from the centerbody at an acute angle relative to the centerbody, and a second cantilever beam extending from the centerbody at an acute angle relative to the centerbody. The first cantilever beam includes a free end that extends over an adjacent one of the pins.

Another aspect of the present invention includes an apparatus for providing electrical continuity between two objects. The apparatus includes a body with a top surface and a bottom surface, the body defining a plurality of pin receptacles, each receptacle including an aperture and a guiding slot within the body. The apparatus includes a plurality of pins located within the

plurality of receptacles, each pin including a planar centerbody , a first member extending from the centerbody and cooperating with the guiding slot to loosely locate each pin within a corresponding receptacle, and a first cantilever beam extending from the centerbody. The centerbody includes a projection extending from a surface of the centerbody, the projection
5 cooperating with the receptacle to limit sliding motion of said pin within the receptacle.

These and other aspects of the present invention will be apparent from the claims, drawings, and the description of the preferred embodiment to follow.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective exploded view of an electronic assembly according to one embodiment of the present invention.

5 FIG. 2 is a perspective view of the connector assembly of FIG. 1 according to one embodiment of the present invention.

FIG. 3 is a top view of the connector assembly of FIG. 2.

FIG. 4 is a partial, cross-sectional side elevational view of the connector assembly of FIG. 3 as taken along line 4-4 of FIG 3.

10 FIG. 5 is a side-elevational view of the connector assembly of FIG. 4 with the pins removed.

FIG. 6 is a cross-sectional, front elevational view of the connector assembly of FIG. 3 as taken along line 6-6 of FIG. 3.

FIG. 7 is a partial bottom view of the connector body of FIG. 3, with the pins removed.

15 FIG. 8 is a top, side, and frontal perspective view of a connector pin according to one embodiment of the present invention.

FIG. 9 is a side elevational view of the pin of FIG.-8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

One embodiment of the present invention includes a connector assembly for providing electrical continuity between arrays of contacts on two objects, such as between an electrical component and a printed circuit board, or two printed circuit boards or two electrical components. The connector assembly includes a plurality of floating pins. Floatation of the pin within a receptacle of the component body provides a first mode of compliance or correction for electrical components, connector assemblies, and printed circuit boards that are not coplanar. For a second mode of compliance or correction to account for non-planarity, each pin includes an elongated, elastically deformable cantilever beam. Each pin is adapted and configured to accommodate the deformed cantilever beam of an adjacent pin without mechanical or electrical contact or interference.

FIG. 1 is an exploded, perspective view of an electronic assembly 20 according to one embodiment of the present invention. Assembly 20 includes a heat sink or cap 25 placed on top of an electronic component 30. Electronic component 30 may be of any type, including various land grid arrays (LGA) containing integrated circuits packaged therein. The bottom side of

electronic component 30 includes a two dimensional arrangement (in rows and columns) of electrical contact pads 34 that are in electrical communication with the integrated circuits contained within component 30. The various signals from the integrated circuits contained within component 30 are communicated by a land grid array connector assembly 35 to various contacts 49 located on a printed circuit board 45. An attachment frame 40 includes a central aperture 41 in which LGA connector assembly 35 is located. A plurality of fasteners (not shown) cooperating with fastener holes 27, 42, and 47 maintain assembly 20 in a compressed, assembled state. In another embodiment of the present invention, connector assembly 35 includes four ears projecting from each corner of the assembly, each ear including a corresponding fastener hole that aligns with holes 27 and 47. Assembly 20 is useful for methods including electrical testing and component burn-in of component 30. LGA connector assembly 35 provides reliable, temporary electrical communication between LGA component 30 and printing circuit board 45 in a manner which will be described.

With reference now FIGS. 2, 3, and 4, a connector assembly 35 according to one embodiment of the present invention is shown. Connector assembly 35 includes a body 100 which defines a plurality of pin receptacles 105 therein. Preferably, each of the plurality of receptacles 105 includes an elastically deformable pin 200 which provides electrical continuity from a contact 34 of component 30 to a contact 49 of printed circuit board 45. As best seen in FIG. 3, receptacles 105 are arranged in a plurality of columns in a first direction 201, and a plurality of rows in a second direction 202, such as to form a two dimensional matrix of receptacles 105 and corresponding pins 200.

In a preferred embodiment, body 100 is molded from a non-conductive material such as Vectra E130i. A preferred embodiment includes a spacing of .050 inches between adjacent

columns, and a preferred spacing of .050 inches between adjacent rows. In yet another embodiment, the preferred spacing between adjacent rows is 1 millimeter, and the spacing between adjacent columns is 1 millimeter. Preferably, the height of body 100 from planar upper surface 110 to planar lower surface 115 is approximately 1.065 inches.

5 Various materials and dimensions are described herein. These materials and dimensions are given as examples, and are intended to be non-limiting examples.

Referring to FIG. 4, in a preferred embodiment each receptacle 105 includes a corresponding pin 200 loosely located therein. Each receptacle 105 includes an aperture 106 located therein that extends from top surface 110 to bottom surface 115. The top portion 106a of
10 aperture 106 extends along direction 201 for a distance longer than the distance which bottom portion 106b of aperture 106 extends along that same direction. Thus, as best seen in FIG. 4 and 5, aperture 106 has the appearance of a sideways "L".

Referring to FIGS. 5, 6, and 7, each receptacle 105 preferably includes a pair of enclosed guiding slots 120 and 125 located along either side of receptacle 105 (as best seen in FIG. 6), and
15 a bottom-facing surface 130 located between guiding slots 120 and 125. Slot 120 includes a bottom-facing aperture 121 and a top-facing aperture 122. Guiding slot 125 includes a bottom-facing aperture 126 and a top-facing aperture 127. Each guiding slot 120 and 125 preferably defines an internal channel from the bottom-facing aperture to the top-facing aperture which is preferably square in cross section with a dimension of .0055 inches X .0055 inches. A top
20 surface 111 of body 100 extends between top-facing apertures 122 and 127.

FIGS. 8 and 9 show perspective and side elevational views, respectively, of a pin 200 according to one embodiment of the present invention. Each pin 200 includes a centerbody 205 having top edges 210a and 210b, and bottom edges 215a and 215b. Centerbody 205 is

preferably planar and manufactured from sheet material. Each centerbody 205 includes front and rear planar surfaces 206a and 206b, respectively.

Each pin 200 includes a first cantilever beam 220 extending from the top edge of the centerbody 205 and a second cantilever beam 230 extending from the bottom edge of the centerbody 205. First cantilever beam 220 extends relative to a planar surface of centerbody 205 at an acute angle 221. Second cantilever beam 230 extends relative to a planar surface of centerbody 205 at an acute angle 231. Preferably, angle 221 is greater than about 40 degrees, less than about 75 degrees, and most preferably is about 52 degrees. Angle 231 is preferably more than about 45 degrees, less than about 80 degrees, and most preferably is about 64 degrees.

Top cantilever beam 220 includes a free end 225 which is adapted and configured to have an external surface which provides electrical continuity with a contact 34 of component 30. Second cantilever beam 230 preferably includes a free end 235 adapted and configured to have an outward surface for providing electrical continuity with a contact 49 of printed circuit board 45. In a most preferred embodiment, free end 225 is formed to have a radius on the inward surface of about .010 inches, and free end 235 is formed to have a radius on the inward surface of about .0075 inches.

Top cantilever beam 220 preferably has a width which varies from approximately .015 as it extends out from centerbody 205, and tapers to about .006 to .008 near free end 225.

Preferably, second cantilever beam 230 has a constant width of about .013 inches. Preferably,

pin 200 is fabricated from a material with good spring characteristics and high conductivity, such as #25 BeCu, ½ hard, and age hardened with a tensile strength between 185 to about 215 KSI. Preferably, the material has a thickness of about .0042 inches.

Referring to FIG. 9, first cantilever beam 220 has a length that is longer than the length of second cantilever beam 230. The furthest most edge of free end 225 is preferably about .055 inches from planar surface 206b of centerbody 205. The furthest edge of free end 235 is preferably about .025 inches from planar surface 206b. Therefore, free end 225 is horizontally
5 displaced from free end 235 by about .03 inches. Referring to FIG. 1, this offset results in a similar offset in apparatus 20, such that a corresponding contact pad 34 of component 30 is offset horizontally from the corresponding contact 49 of circuit board 45. Referring to FIG. 4, each pin 200 includes a first cantilever beam adapted and configured to have a free end 225 that extends over the centerbody 205 of the adjacent pin.

10 Each pin 200 also includes features to guide and limit sliding of pin 200 within a receptacle 105 of body 100. Each pin 200 includes first and second members 240 and 245, respectively, extending from edge 210 of centerbody 205, and straddling cantilever beam 220. Each member 240 and 245 is generally coplanar with centerbody 205, as best seen in FIG. 9. Cantilever beam 220 extends from a central portion of one edge of centerbody 205, with first
15 member 240 extending from the edge adjacent to one side of the cantilever beam and second member 245 extending from the edge adjacent to the other side of cantilever beam 220.

Centerbody 205 includes a projection 250 that extends from planar surface 206b of centerbody 205, as best seen in FIGS. 8 and 9. Projection 250 extends about .0024 inches from planar surface 206b.

20 As seen in FIG. 4, pins 200 are in the free state, with free end 225 being above top surface 110, and free end 235 of second cantilever beam 230 being below bottom surface 115. However, when connector assembly 35 is used as shown in apparatus 20 of FIG. 1, the bottom surface of electronic component 30 deflects each first cantilever beam 220 downward until the

top most surface of free end 225 is at or near the plane defined by top surface 110. Likewise, contact with the surface of printed circuit board 45 deforms free end 235 of second cantilever beam 230 so that the exterior surface of free end 235 is at or near a plane defined by bottom surface 115.

5 However, contact pressure against second cantilever beam 235, owing to its greater stiffness as compared to first cantilever beam 220, also results in limited upward sliding motion of pin 220 within guiding slots 120 and 125 of receptacle 105. As best seen in FIG. 4, the first member 240 extending from centerbody 205 is slidably received within a guiding slot 120 of the corresponding receptacle. Likewise, the second member 245 extending from centerbody 205 is
10 slidably received within second guiding slot 125. The cooperation of first and second members 240 and 245 with guiding slots 120 and 125, respectively, limit sliding motion of pin 200 within receptacle 105 to a vertical orientation (as seen in FIG. 4). However, the loose sliding motion of pin 200 within receptacle 105 is limited. Still referring to FIG. 4, sliding motion in the downward motion is limited by contact of cantilever beam 220 with a surface 131 of body 100.
15 Upward sliding motion of pin 200 within receptacle 105 is limited by contact of projection 250 with surface 130 of body 100.

 Owing to the greater stiffness of cantilever beam 230 as compared to cantilever beam 220, compression of connector assembly 35 between a component 30 and printed circuit board 45 results in beam 230 tending to push pin 200 vertically upward. This upward motion is limited
20 by contact of projection 250 with surface 130. In contrast, contact of component 30 with the more easily deformable beam 220 tends to result in deformation of beam 220. As previously described, beam 220 is both tapered in width and also longer than beam 230, such that beam 220 is less resistant to bending than beam 230.

Referring to FIGs 1 and 4, compression of a connector assembly 35 between a first object such as electrical component 30 and a second object such as printed circuit board 45 results in both vertical movement and deformation of pins 200. Owing to the greater stiffness of beam 230, contact of beam 230 with an object results in a first, lesser amount of upward bending and also vertical sliding movement of pin 200 within the guiding slots. This sliding movement is limited by contact of projection 250 with surface 130. Owing to the lesser stiffness of beam 220, contact of beam 220 with an object results in a second greater amount of downward bending. The downward bending movement of free end 225 of beam 220 is limited by contact of the inner surface of end 225 with top surface 111 of body 100. Further, beam 220 deflects to a recessed position between members 240 and 245 (which are slidably received within the insulative body material of slots 120 and 125). This combination of contact of free end 225 with surface 111 of a first pin 220, the limited upward sliding movement of a second adjacent pin 200, and the deflection of the upper beam of the first pin to a recessed portion of the adjacent second pin prevents the shorting of adjacent pins 200 in apparatus 20. Thus, even though the beam 220 of a first pin overhangs the centerbody 205 of an adjacent second pin, each pin includes features that prevent inadvertent electrical contact.

The long length of upper beam 220 also improves the degree of contact between the pin and the electrical contacts of some objects by providing a wiping action. As an example, as beam 220 is elastically deformed downward by mating of assembly 35 and component 30, the free end 225 of beam 220 also moves laterally with respect to component 30. This lateral motion of free end 225 wipes against the corresponding contact of component 30, and in some cases mechanically removes any oxidation layer that has formed on the contact of the object. This oxidation layer is noted on board or IC contacts that have been tin plated. Removal of at least

some of the oxidation layer reduces the contact resistance between the component contact and the free end of the pin.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character,
5 it being understood that only the preferred embodiment has been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.